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Use of Temporary Peripheral Nerve Stimulation for Management of Recalcitrant Pain in Patients With Complex Regional Pain Syndrome: Case Series and Literature Review

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Background: Complex regional pain syndrome (CRPS) is a chronic pain syndrome involving autonomic, sensory, motor, and sudomotor dysfunction. Its pathophysiology involves both central and peripheral nervous systems, with a constant interplay between multiple mechanisms. Treatment for CRPS varies from pharmacological choices, physical therapy, and sympathetic blocks to neuromodulation techniques, namely use of spinal cord stimulation, dorsal root ganglion stimulation, and peripheral nerve stimulation (PNS).

Case Report: We present a case series detailing the use and efficacy of temporary PNS for management of CRPS in 3 patients.

Conclusions: PNS has been observed to help in neuropathic pain associated with CRPS by affecting both central and peripheral pain pathways.

Key words: Complex regional pain syndrome, CRPS, peripheral nerve stimulation, neuromodulation, SPRINT, PNS, chronic pain, neuropathic pain

BACKGROUND

Complex regional pain syndrome (CRPS) is a chronic pain syndrome with an estimated prevalence of 5.4-26.2 per 100,000 persons (1). CRPS exhibits a highly variable clinical presentation and involves autonomic, sensory, motor, and sudomotor dysfunction, which usually presents as allodynia, edema, and sensory & motor function loss, along with skin color and temperature changes (2). CRPS has been classified into 3 types: CRPS I, previously known as reflex sympathetic dystrophy, which is associated with injury of an unidentified nerve; CRPS II, previously known as causalgia, which is associated with injury of an identified nerve; and a third recently identified but less diagnosed subtype, CRPS not otherwise specified, which includes patients who demonstrate fewer than 3 symptoms or 2 signs, or who were not showing a sign at the time of the examination, but had exhibited this previously, and whose signs and symptoms were felt to be best explained by CRPS that display some features of CRPS without completely satisfying diagnostic criteria(3,4).

Its The pathophysiologyof CRPS involves both central and peripheral nervous systems, with multiple mechanisms, namely, inflammation, altered cutaneous innervation, altered sympathetic nervous system, changes in circulating catecholamines, autoimmunity, altered brain plasticity, and genetic and psychological influences playing a role in CRPS development of CRPS in a patient (5-8). Its treatment varies from conventional choices like phar-

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macological management (with steroids, nonsteroidal anti-inflammatory drugs [NSAIDs], and anticonvulsants like gabapentin & pregabalin), physical therapy, sympathetic blocks to recent neuromodulation techniques like spinal cord stimulation (SCS), dorsal root ganglion stimulation (DRGS), and peripheral nerve stimulation (PNS) (9). Despite being used for > 50 years for the management of chronic pain, it was only in 2015 that the US Food and Drug Administration (FDA) approved PNS for management of recalcitrant chronic pain (10).

Herein, we present a case series where the SPRINT® PNS device (SPR® Therapeutics, Inc., Cleveland, OH) was efficacious in the management of CRPS. Written informed consent was obtained from all the patients for inclusion in this case series.

CASES

Case 1

A 55-year-old man presented with the chief complaint of chronic pain in his left arm. Patient's medical history was significant for atrial fibrillation, nonalcoholic fatty liver disease, alcohol abuse, left above-knee amputation, and a left-sided brachial plexus injury. The patient reported that In May 2020, the patient was involved in a motor vehicle crash during which he sustained an injury to his left brachial plexus and a fracture of his left femur and patella. Patient's first evaluation for pain in his left upper extremity (LUE) was done in April 2021 (as patient was in a different country at the time of accident and came back to the United States in 2021), during which significant atrophy of his entire LUE (proximal to distal) with no noticeable active range of motion at the left shoulder and loss of elbow flexion were noted. He also reported reduced muscle strength, poor hand function, dysesthesia elicited on light touch, along with trophic changes of his skin and nails. Magnetic resonance imaging (MRI) demonstrated possible avulsion of C6, C7 nerve roots with concomitant injury of C8; edema of left supraspinatus, infraspinatus, subscapularis, deltoid, and pectoralis musculature, consistent with acute denervation. Electromyography was remarkable for involvement of the lower trunk and medial cord. Subsequently, he was diagnosed with CRPS I of LUE (per set of accepted guidelines adopted by the International Association for the Study of Pain in 2004 [Budapest Criteria]), owing to presence of diffuse pain in his LUE spanning from C5-T1 dermatomes. A multimodal approach, involving physical therapy, pharmacotherapeutic management (NSAIDs, pregabalin, clonidine), and mirror therapy, was employed, which provided only partial relief to the patient.

Fractures to the patient's left lower extremity (LLE) required frequent hospital admissions and multiple surgeries (total of 18 procedures on LLE), with the patient eventually undergoing left above-the-knee amputation in October 2022. Unfortunately, postamputation, the patient developed phantom pain in his LLE, which exacerbated his already existing neuropathic pain in the LUE. Upon discussion with the patient, a stellate ganglion block with ultrasound guidance was done to help alleviate his neuropathic pain. However, he reported no pain relief and mentioned that pain in his LUE was very severe in intensity and was limiting his ability to use his hands for any activity of daily living. With shared decision-making, a plan to use PNS for management of pain in the LUE was agreed upon. In July 2024, the patient underwent placement of a SPRINT PNS lead over the left brachial plexus via the interscalene approach under ultrasound guidance. He responded favorably and reported immediate, 100% relief in his shoulder pain and 80% relief in his pain in the LUE.

Case 2

A 72-year-old woman presented with the chief complaint of chronic pain in her right arm. The patient's Her medical history was significant for fracture of the right elbow (twice, in 2018 and 2024), which were sustained after a fall and were managed by surgical fixation, in addition to chronic neck pain being managed by C5-C7 decompression & fusion, anxiety, depression, and hypertension. Patient sustained a fracture of her right elbow in 2018 which required surgical fixation. Even after the surgical fixation, she Patient reported a constant feeling of discomfort in her right arm after the surgical fixation in 2018, which only got exacerbated after her second elbow fracture in 2024. Unfortunately, she had another fall in October 2024, during which she sustained another fracture to her right olecranon, necessitating surgical fixation. However, it resulted in an exacerbation of pain in her right arm, Her pain which was diffuse in nature with an intensity of 9/10 (Visual Analog Scale [VAS]), and was associated with numbness and trophic changes in her first 2 digits. Patient reported increase in her pain with any movement involving her right shoulder & elbow, and relief in pain with lying down.

Prior to her clinic visit, the patient had already trialed physical therapy and medications (opioids, NSAIDs, gabapentin) with no success. Based on her chart review, she was diagnosed with CRPS I (per the Budapest Criteria) in her right upper extremity, and she subsequently underwent placement of a SPRINT PNS device to the right brachial plexus via the interscalene approach under ultrasound guidance. She responded positively to the use of PNS and reported 50% pain relief at her one-month follow-up visit.

Case 3

A 37-year-old male patient presented with the chief complaint of chronic pain in his LUE, status post multiple gunshot wounds to his face, left clavicle, left arm, and right side of abdomen. Prior to his presentation in the pain clinic, the patient had undergone left orbital enucleation, bifrontal craniotomy, and cranialization of frontal sinus at an outside hospital, and had already trialed medications for pain in his LUE. His LUE pain was constant in nature with an intensity of 10/10 (VAS). He mentioned pain radiating from his elbow to all the fingertips, with associated numbness, trophic and vasomotor changes in the entire forearm. His pain was aggravated by even the slightest movement of his LUE and was relieved with ice and lidocaine cream. He was diagnosed with CRPS I (as per the Budapest Criteria) in his LUE, and after shared decision-making, he underwent placement of a SPRINT PNS device to the left brachial plexus via the interscalene approach under ultrasound guidance. Patient responded positively to the use of PNS and reported immediate 90% pain relief.

Technique

The procedure was done with the patient in the sitting position. Overlying skin was prepped and draped in sterile fashion using ChloraPrep™ (Becton, Dickinson and Company). Patient was asked to turn the head to the contralateral side. A 15 Hz linear ultrasound transducer was used to identify the common carotid artery, external jugular vein, and internal jugular veins, along with the sternocleidomastoid, anterior scalene, and middle scalene muscles. At the level of the clavicle, the probe was pointed down to identify the subclavian artery and the brachial plexus being traced superiorly until the interscalene groove between the anterior scalene and the middle scalene, at which point the C5 and C6 nerve roots were seen. The skin around the planned entry point and the subcutaneous tissues were injected with local anesthetic. A percutaneous sleeve and stimulating probe lead introduction system were assembled, inserted posteriorly in the trapezius muscle, and advanced through the middle scalene muscle, taking care to maintain the proper depth of insertion as the introducer is advanced under ultrasound guidance. The introducer needle was delivered to a location between the C5 and C6 nerve roots.

Multiple stimulation parameters were used to deliver stimulation to the brachial plexus. Nerve target acquisition was confirmed by noting generation of paresthesia in the shoulder, arm, and forearm. Various electrical parameter combinations were tested, and the lead location was adjusted until the patient indicated paresthesia overlapping the distribution of the patient's typical region of pain. The stimulating probe was removed from the introducer, and a percutaneous lead was guided through the needle and delivered to a location in similar proximity to the nerve. Final location was verified with electrical stimulation and documented with ultrasound. The introducer needle was removed, and the exposed end of the percutaneous lead was attached to an external stimulator unit. Various electrical parameter combinations were again tested until paresthesia overlapping the distribution of the patient's typical region of pain was noted. After confirming that lead impedance was in the normal range, the external stimulator unit was detached, needle was removed, and the lead was anchored at the skin with DermaBond (Ethicon, Inc., Somerville, NJ). The lead was threaded into the connector block, and electrical continuity and desired patient response was confirmed. The connector block was attached to the external stimulator unit, and site was covered with a sterile occlusive dressing.

DISCUSSION

The earliest use of PNS for chronic pain management dates to the 1960s, when Shelden et al reported temporary pain relief in patients with trigeminal neuralgia (11). However, with the recent technological advances in the early 2000s, most notable being PNS placement via a percutaneous approach rather than surgical dissection, PNS has become more desirable for the treatment of recalcitrant chronic pain (10,11). PNS comprises a battery-powered pulse generator that delivers stimulation through an electrical lead placed near the targeted nerve. As a neuromodulation technique, PNS has been hypothesized to work by affecting both central and peripheral pain pathways. The electrical stimulation of the targeted nerve seems to interfere with the afferent pain signals to the spinal cord (12). Chakravarthy et al (13) and Slavin et al (14) have suggested that PNS could potentially also alter the stimulatory threshold of peripheral nerve fibers by modulating the concentration of local biochemical neurotransmitters and suppression of peripheral neurogenic inflammation. Additionally, PNS has also been shown to reduce endogenous pain perception by acting on GABAergic, glycinergic, and 5-HT2/3 pathways, with the repetitive PNS also inhibiting the spinothalamic tract neurons and the medial lemniscus pathways and by reducing hyperalgesia & central sensitization by the reduction of Aß neuronal activity (14,15). Deer et al (16) have suggested peripherally induced reconditioning of the central nervous system as the reason for sustained relief with use of PNS. They hypothesize activation of the descending pain inhibitory system through modulation of the pregenual anterior cingulate cortex, which has been substantiated by studies correlating electroencephalography and functional MRI studies documenting changes in cortical activation with dorsal column stimulation (16).

Currently, we have 5 FDA-approved, commercially available models for use in the United States (10). SPRINT PNS System is an FDA-approved, temporary, noninvasive device, which includes a short-term, 60-day treatment designed to deliver long-lasting pain relief. Its electrical lead has a helical configuration, which helps to reduce the commonly seen side effects of lead migration and infection (12). In this case series, we used ultrasound to provide appropriate guidance for insertion of the electrical lead, while minimizing the risk of nerve damage. McNaught et al (17) made an analogous observation about the use of ultrasound guidance and opined that a more superficial approach is made possible, which helps to avoid the bulk of the muscles in the back of the neck, leading to a decrease in the amount of pain associated with the procedure. Frederico et al (18) and Bouche et al (19) have also trialed brachial plexus stimulation by PNS and reported satisfactory pain reduction in patients with CRPS in the upper extremities.

Elsamadicy et al (2) discussed the economic health care burden associated with the diagnosis and management of CRPS. Currently, neuromodulation interventions are adopted after the failure of conservative medical management, which adds to the overall expenditure. For a chronic pain diagnosis like CRPS, which often has recalcitrant pain refractory to conservative management, earlier use of neuromodulation interventions could potentially help to lower the financial burden.

CONCLUSIONS

In comparison to SCS & DRGS, PNS offers the advantage of avoidance of surgical dissection. Currently, PNS is being used for treatment of localized pain conditions limited to one or two peripheral nerve distributions, but with the evolution of technology, we anticipate that it would also be able to help patients with more diffuse and complex pain patterns.

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